BELLCOMM, INC.
1100 Seventeenth Street, N.W. Washington, D.C. 20036

SUBJECT: Coverage for an Uprated Saturn I Provided by the MSFN for a Launch on a 46° Launch Azimuth Case 600-2

DATE: September 20, 1967

FROM: J. P. Maloy

MEMORANDUM FOR FILE

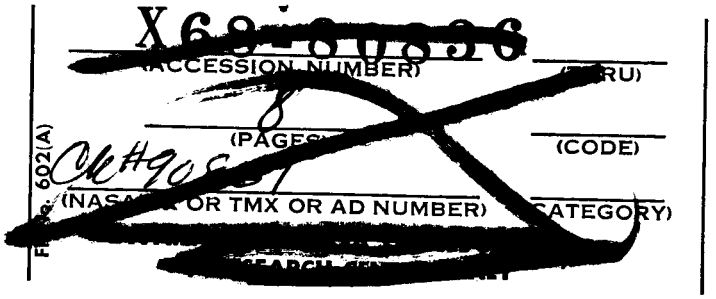
Introduction

It is anticipated that some AAP missions will fly on orbital planes which will have inclination angles of approximately 48° to the Earth's equatorial plane. The effects of these high inclinations on the coverage provided by the MSFN during the launch phase were studied and the results are summarized in this memorandum. This plane inclination is outside of the range of inclinations used or planned for Apollo missions (28.4° to 32.2°) and is related to a launch azimuth of 46°.

Procedure

Since the subvehicle track of such a launch (see Figure 3) would be significantly farther north than formerly considered, new locations for USB tracking facilities on land and at sea were examined. Table I lists all the locations examined in this study. They include five ship locations; used to determine approximately where the better locations are for insertion coverage, and in conjunction with land stations where the better positions are during launch. Six land locations were considered, three existing stations that would provide coverage for the prescribed launch, namely, MIL, GBM, BDA and three land locations where it might be necessary to locate a USB tracking capability in order to provide continuous coverage during launch as an alternative or a supplement to ships.

A launch trajectory with an inclination angle of 48° for a fully loaded uprated Saturn I was developed by Department 2011 for use in this study. (The configuration for a Saturn V vehicle was not known at the time). Trajectory points in relation to time (approximately every twenty seconds), latitude and longitude of subvehicle point, radius vector, roll angle, and an inertial azimuth were used as inputs to the Track II computer program which in turn provided the coverage, look angle, and elevation angle information desired to determine the quantity and something of the quality of the line-of-sight coverage of the stations mentioned above.



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ABSTRACT

The effects on coverage provided by the MSFN for a high inclination launch (launch azimuth of 46°) for an uprated Saturn I were studied and the results are presented in this memorandum. It was determined that continuous tracking coverage above a 5° elevation angle is possible for a 46° launch azimuth at an insertion altitude of 81 nm by using existing tracking facilities.

Two separate launch profiles were used, one for an insertion altitude of 125 nm and the second for an altitude of 81 nm which was felt to be the minimum. If coverage were found to be sufficient at the minimum altitude, then all other cases of higher altitude would have better coverage. A 5° elevation angle, and a 10° look angle (from vehicle roll axis) were considered minimum for good tracking coverage. A 10° keyhole in the North-South direction was taken into account for land stations. Ships would have a similar size keyhole directly overhead, but they could be stationed off the vehicle's suborbital track and hence eliminate any interruption in coverage.

Results

The pertinent results are shown graphically in Figures 1 and 2 for the insertion altitudes of 125 nm and 81 nm. Since the latter is the critical case, it will be discussed in more detail here. In general, the look angles between the two figures do not change significantly although the 5° elevation points do change noticeably after 200 seconds. In order to avoid clutter, not all the ship positions for which data was calculated are plotted; a representative sample for an insertion ship and one located closer to the launch point which would fill a possible coverage gap are shown. These ship positions were not optimized, but it is apparent that in conjunction with coverage from Bermuda, a ship could be located such as ship #5 that would provide overlapping coverage above a 5° elevation angle with more than adequate look angles and yet still be able to provide three minutes of tracking coverage after insertion. The amount of coverage at 81 nm for a near overhead pass would approach five minutes. Ship #5 in Figure 2 indicates 70 seconds of coverage before insertion, leaving a balance of over three minutes for communications after insertion.

A second ship that could be deployed, if available, (Ship #4 in this study) between Cape Kennedy and Bermuda if coverage from Grand Bahama were not available and no other land station was developed for USB tracking. This ship location would pick up the vehicle at 5° elevation while the look angles from MIL were still above the minimum of 10° and pass tracking responsibility to BDA before its own look angles become prohibitive. A USB tracking station located at Jacksonville would do essentially the same thing. Tracking sites at Wallops or Goddard would not acquire the vehicle at 5° elevation (250 sec.+) angles before Cape Kennedy's look angles became marginal (150 sec.).

Conclusions

Continuous tracking coverage of an uprated Saturn I above a 5° elevation angle is possible for a 48° inclination launch trajectory at an insertion altitude of 81 nm by using existing tracking facilities; namely - MIL, GBM, BDA and one ship positioned at 41° N and 60° W.

A second ship could be positioned between MIL and BDA that would obviate the requirement for communications coverage at GBM.

J. P. Maloy

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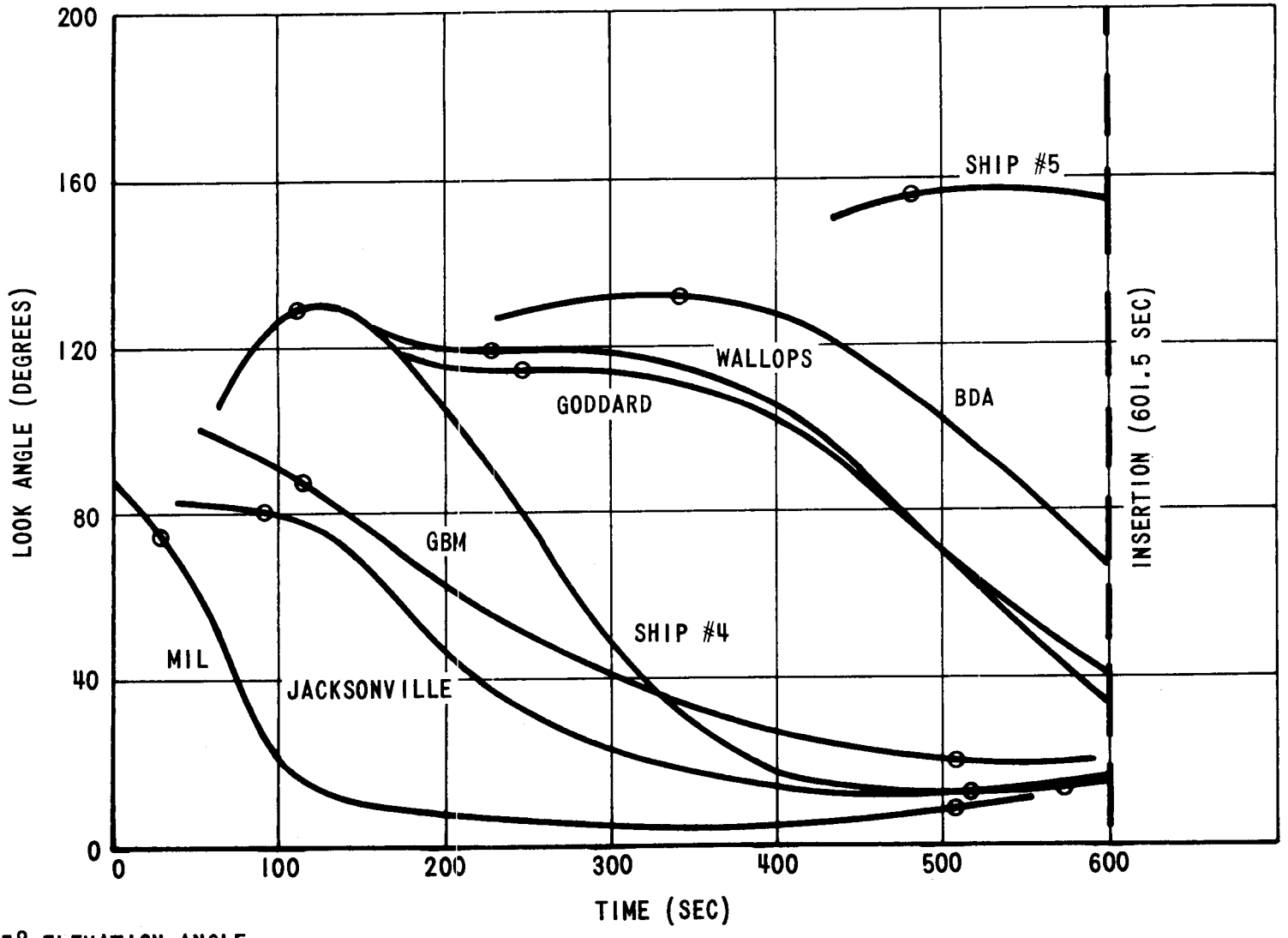
Attachments

TABLE I

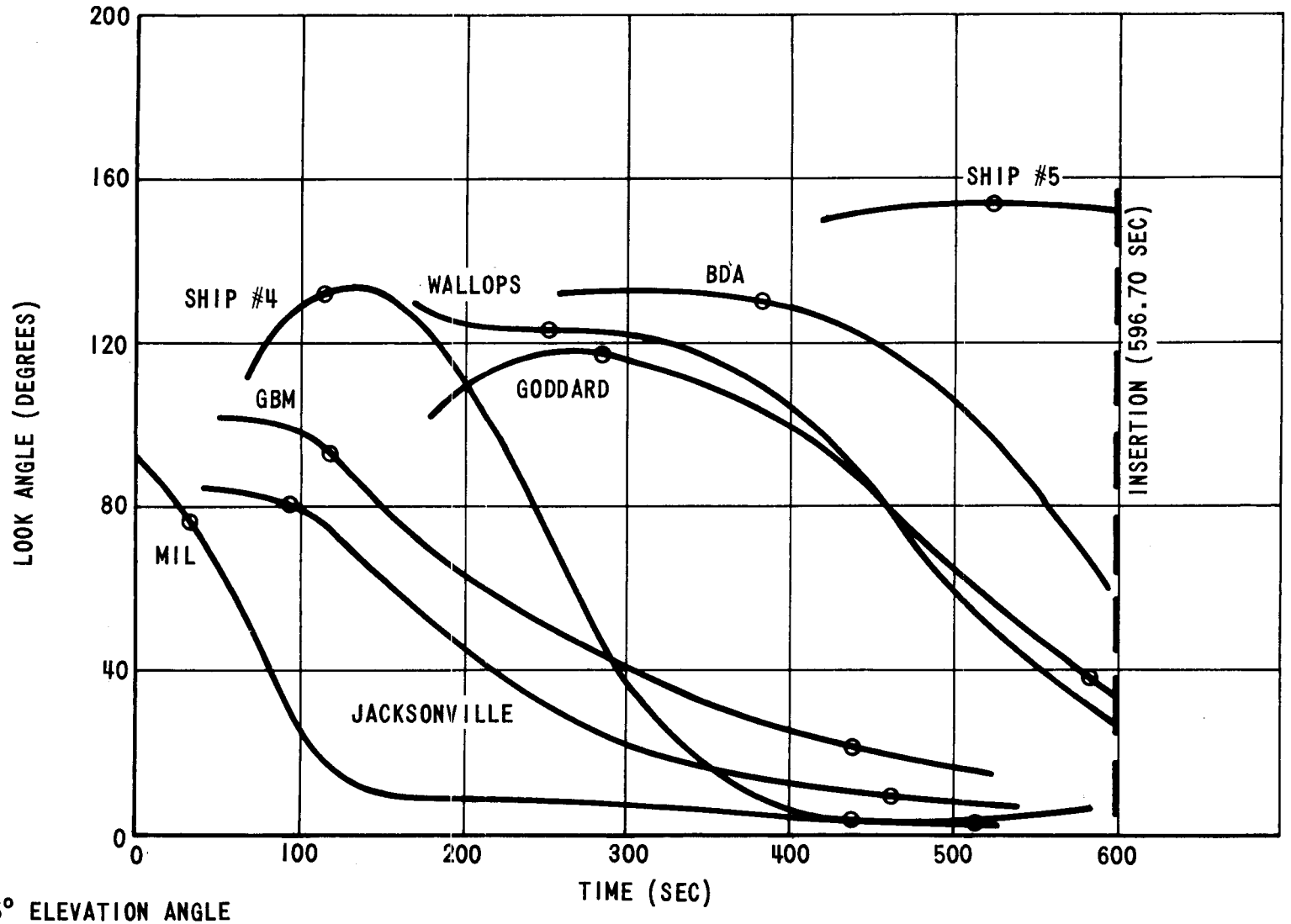
STATION LOCATIONS

	STATION	LATITUDE°	LONGITUDE°
1.	Cape Kennedy (MIL)	28.5083	279.3067
2.	Jacksonville	30.3667	278.3667
3.	Grand Bahama Island (GBM)	26.6258	281.6521
4.	Bermuda (BDA)	32.3475	295.3464
5.	Wallops	37.8561	284.4883
6.	Goddard	38.9792	283.1427
7.	Ship Position #1	38.5364	294.3751
8.	Ship Position #2	36.7393	291.0464
9.	Ship Position #3	40.0000	298.0000
10.	Ship Position #4	30.8500	282.1200
11.	Ship Position #5	41.0000	300.0000



O - 5° ELEVATION ANGLE

FIGURE 1 - LOOK ANGLES vs. TIME FOR UPRATED SATURN I LAUNCH TRAJECTORY WITH INSERTION ALTITUDE OF 125 NM



O - 5° ELEVATION ANGLE

FIGURE 2 - LOOK ANGLES vs. TIME FOR UPRATED SATURN I LAUNCH TRAJECTORY WITH INSERTION ALTITUDE OF 81 NM

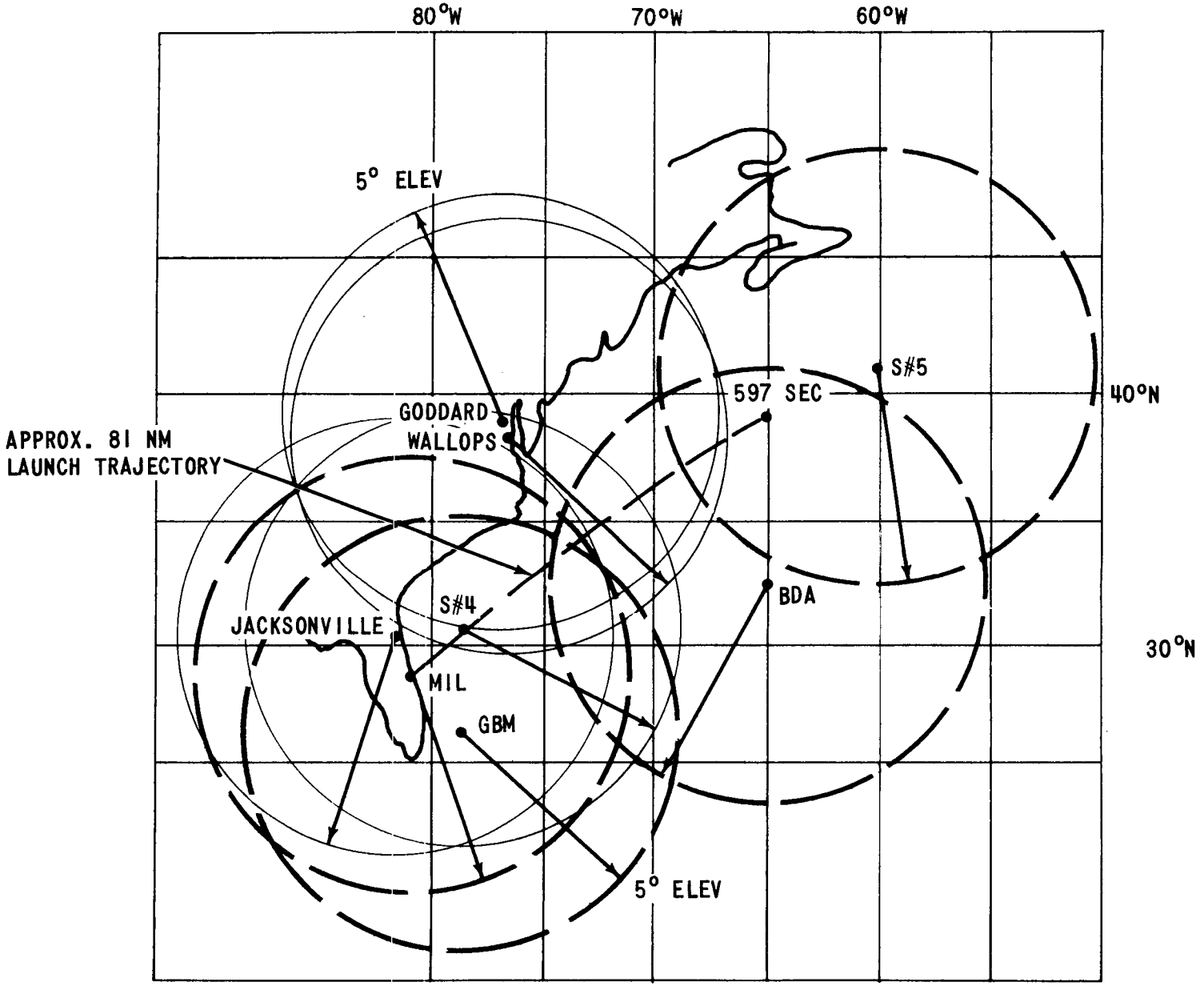


FIGURE 3

COVERAGE PROVIDED BY SELECTED STATIONS
81 NM ALT; 5° ELEV.

— — — STATIONS THAT PROVIDE CONTINUOUS LAUNCH COVERAGE AND ACCEPTABLE LOOK ANGLES